INDOOR AIR QUALITY ASSESSMENT

Essex Elementary and Middle School
12 Story Street
Essex, MA 01929

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
May 2005

Background/Introduction

At the request of Roger Young, Business Manager, Manchester Essex Regional School District, the Massachusetts Department of Public Health (MDPH)'s Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at the Essex Elementary School (EES), 12 Story Street, Essex, Massachusetts. On May 7, 2004, a visit to conduct an indoor air quality assessment was made to this school by Sharon Lee, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality Program (ER/IAQ).

The EES is a single story brick building constructed in 1956. An addition containing the gym and library was constructed in 1976. Art and technology rooms occupy the basement. Classroom windows are openable throughout the building. Modular classrooms connected to the main building were added to the school around 2003. The modulars are the subject of a separate report. The main building is the subject of this report.

An indoor air quality investigation was conducted by an environmental consultant, HUB Testing Laboratory (HUB), on November 11, 2003. Their report indicated that carbon dioxide levels in many areas were elevated (HUB, 2003). No specific recommendations for remediation of the ventilation system were made in the HUB report.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). MDPH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The school complex houses approximately 350 kindergarten through eighth grade students and approximately 75 staff members. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 ppm in 10 of 30 areas surveyed, indicating inadequate air exchange in some areas. It is important to note that several areas were empty or sparsely populated and/or windows and exterior doors were open in many areas at the time of assessment. Low room occupancy and open windows/exterior doors can greatly reduce carbon dioxide levels. However, carbon dioxide levels in some rooms were elevated despite open windows, further indicating inadequate air exchange.

Fresh air in classrooms is supplied by unit ventilator (univent) systems (Pictures 1 and 2). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 3) and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents were not operating throughout the school at the time of the assessment. Obstructions to airflow, such as desks and other items located on or in front of univents, were also observed (Picture 4). To function as designed, univents must remain free of obstructions and allowed to operate.

Exhaust ventilation is provided by wall-, closet- or ceiling-mounted exhaust vents (Pictures 5 and 6), which are ducted to motorized rooftop fan units (Picture 7). Exhaust vents were either off, drawing weakly and/or blocked with materials in a number of classrooms surveyed (Picture 8). In addition, some wall vents are located near hallway doors (Picture 6). When hall doors are open, the exhaust is apt to draw hallway air rather than classroom air. As with the univents, exhaust vents must remain free of obstructions and allowed to operate. Classroom doors should also remain closed to facilitate air exchange.

Please note, some areas do not have mechanical or passive ventilation or openable windows (Table 1). A fresh air source is necessary for the dilution of indoor air pollutants. Without a source of fresh air, pollutants will persist in the indoor environment. This may lead to indoor air quality/comfort complaints.

To maximize air exchange, the MDPH recommends that ventilation equipment operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last servicing and balancing was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied.

Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

The temperature measurements ranged from 71° F to 80° F, which were within or slightly above the MDPH recommended comfort guidelines (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, temperature control is often difficult without operating the ventilation systems as designed (e.g., univents/exhaust vents deactivated/obstructed).

The relative humidity measurements ranged from 42 to 56 percent, which were within the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. The sensation of dryness and irritation is common in a low relative humidity environment. Relative humidity levels in the building would be expected to drop during the winter months due to heating. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of rooms had water-stained ceiling tiles, indicating roof and/or plumbing leaks (Picture 9). Water-damaged ceiling tiles can provide a source of mold growth and should be replaced after a water leak is discovered and repaired. The school has a ceiling tile system where tiles are glued directly to the ceiling. Replacement of these ceiling tiles is difficult, since their removal appears to necessitate the destruction of the tile. Appropriate measures should be taken to minimize the aerosolization of particulates from tile removal/replacement.

The American Conference of Governmental Industrial Hygienists (ACGIH) and United States Environmental Protection Agency (US EPA) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If items are not dried within this time frame, mold growth may occur. The application of a mildewcide to mold colonized porous materials is not recommended.

Plants were noted in several classrooms. Some plants were placed near ventilation sources (Picture 10), while others were placed on porous materials (Picture 11). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold. Plants should also be properly maintained and equipped with drip pans.

Efflorescence was noted on walls of the ramp way leading to the art area (Picture 12). The ramp way is built below ground and the exterior portion of the wall is in contact with soil (Picture 13). Efflorescence is a characteristic sign of water damage to building materials such as cement or plaster, but it is not mold growth. As moisture penetrates and works its way through exterior walls, water-soluble compounds dissolve, creating a solution. As the solution moves to the surface of the interior wall, water evaporates, leaving behind white, powdery mineral deposits. Efflorescence noted on these walls is likely the result of moisture from the soil in contact with the building.

To prevent groundwater seepage, this area was constructed with a series of channels through which groundwater could flow. These channels run along the ramp and through the crawlspace (Picture 14). Water in the channels did not appear to be stagnant at the time of the assessment. However, periodic inspections should be conducted to ensure debris is not blocking or hindering groundwater flow. Disruption of the flow may result in flooding and/or odors.

Several pathways exist for crawlspace air to migrate into occupied areas. Crawlspaces function as chaseways for pipes to run traverse a building. Pipes connect the boiler to classroom univents. MDPH staff randomly examined some univents. Spaces and holes were observed around pipes and within the air handling cabinet. These breaches can serve as pathways to draw air, odors and particulates from exterior wall cavities and the crawlspace into classrooms. Heated air from HVAC system pipes can create drafts that rise from the crawlspace into classrooms. These drafts can also draw mold, spores and associated odors from the crawlspace.

A number of other conditions observed along the building exterior may be conducive to water penetration through the building envelope. One wall in the school courtyard had substantial clinging plant growth (Picture 15). Clinging plants can cause damage to brickwork through the insertion of tendrils into brick and mortar. Water can penetrate into the brick along the tendrils, which can subsequently freeze and thaw during the winter. This freezing/thawing action can weaken bricks and mortar, resulting in damage. This type of plant growth on brickwork is not recommended.

As discussed, a crawlspace is located in the school. The basement level storage area opens to the crawlspace area. The storage and crawlspace areas are accessible either via the technology room or by way of a staircase that leads from the main level to the basement (Picture 16). At the time of the assessment, the door to the storage area was not secured. In addition, the door to the stairway from the main level was open. Open doors, breaches and other openings (e.g., utility holes) allow for crawlspace odors and materials to penetrate occupied areas of the school. Doors should remain closed and breaches should be sealed to prevent movement of materials from the unoccupied storage and crawlspace areas to occupied areas of the school.

Shrubbery and other plants were also observed to be growing in cracks and crevices in close proximity to the foundation walls (Picture 17). The growth of roots against the exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Other Concerns

Indoor air quality can also be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants.

Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

The US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 12 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors were in a range of 13 to 38 $\mu g/m^3$. Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system; cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were ND in all but one area (Table 1). Room D, a resource room near the Psychology office, had a TVOC measurement of 0.2 ppm (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products. While no TVOC levels measured exceeded background levels, materials containing VOCs were present in the school. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

According to occupants in classroom 9, the room experiences a buildup of chemical odors when science laboratory classes are in progress. An auxiliary window exhaust fan was installed to remove odors (Picture 18). Despite operation of the window fan, occupants reported some residual odors when conducting laboratory experiments. Occupants should ensure the fan is operating at least 15-20 minutes prior to and following any laboratory work. In addition, ventilation equipment should be operating at all times a classroom is occupied. At the time of the assessment, the classroom univent was off and the classroom wall exhaust function was being hindered as a result of an open door.

Several other conditions that can affect indoor air quality were noted during the assessment. Univents are normally equipped with filters that strain particulates from airflow. The univent filters at the EES provide minimal filtration of respirable dusts. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow as a result of increased resistance, a condition known as pressure drop. Prior to any increase of filtration, univents should be evaluated by a ventilation engineer to ascertain whether units can maintain function with more efficient filters.

A number of exhaust/return vents, univent supply vents and personal fans were observed to have accumulated dust (Pictures 19 and 20). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles. Re-activated univents and fans call also aerosolize dust accumulated on vents/fan blades.

Of note was the use of food as project materials (Picture 21). Exposed food products and reused food containers can attract a variety of pests. The presence of pests inside a building can produce conditions that can degrade indoor air quality. For example, rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine is known to contain a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms in exposed individuals, including nose irritations and skin rashes. Pest attractants should be reduced/eliminated. Proper food storage is an integral component in maintaining indoor air quality. Food should be properly stored and clearly labeled. Reuse of food containers (e.g., for art projects) is not recommended since food residue adhering to the container surface may serve to attract pests.

In an effort to reduce noise from sliding chairs, tennis balls had been spliced open and placed on chair legs (Picture 22). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Also was the amount of materials stored inside classrooms (Picture 23). In classrooms throughout the school, items were seen on windowsills, tabletops, counters, bookcases and desks. The amount of items stored in classrooms provides a means for dusts, dirt and other potential respiratory irritants to accumulate and make it difficult for custodial staff to clean.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Examine each univent for function. Operate univents while classrooms are occupied. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
2. Examine exhaust vents for function and make repairs as necessary.
3. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.
4. Remove all obstructions from univents and exhaust vents to facilitate airflow. Close classroom doors to improve air exchange.
5. Remove debris and dust accumulated on the ventilation grilles.
6. Consult a ventilation engineer concerning re-balancing of the ventilation systems and the calibration of univent fresh air control dampers throughout the school. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
8. Examine the feasibility of increasing HVAC filter efficiency. Note that prior to any increase of filtration, each unit should be evaluated by a ventilation engineer as to whether they can maintain function with more efficient filters.

9. Identify and repair sources of water leaks. Replace water-damaged ceiling tiles. These ceiling tiles can be a source of microbial growth. Examine the non-porous surface beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial.
10. For removal of tiles directly adhered to the ceiling, such removal would be considered a renovation activity that can release particulates and spores in particular, if the material is moldy. Replacement of ceiling tiles may also involve glues that contain VOCs. In order to minimize occupant exposure, repairs should be done while the building is unoccupied.
11. Examine plants in classrooms for mold growth in water catch basins. Disinfect water catch basins if necessary. Remove plants from ventilation sources.
12. Remove plants growing against building and its foundation to prevent water intrusion through brickwork.
13. Ensure water is flowing in the ramp and crawlspace water channels. Examine and remove any debris that may impede water movement.
14. Operate auxiliary fan in classroom 9 at least 15-20 minutes prior and following any science laboratory projects.
15. Ensure doors leading to the storage and crawlspace remain closed to prevent the movement of odors and materials into occupied areas.
16. Refrain from using food as materials for projects.
17. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
18. Consider discontinuing the use of tennis balls on furniture and replacing tennis balls with alternative “glides”. Refer to Picture 24 for an example.

19. Extend exhaust pipe above ventilation equipment to prevent entrainment of odors and particles.

20. Consider adopting the US EPA document, *Tools for Schools* (US EPA, 2000b), as a means to maintaining a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

21. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://www.state.ma.us/dph/beha/iaq/iaqhoFtme.htm.

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Picture 1

Univent

Picture 2

Univent

Picture 3

Univent fresh air intake

Picture 4

Obstructions to classroom univents

Picture 5

Closet exhaust vent

Picture 6

Exhaust vent, note proximity to hallway door

Picture 7

Rooftop exhaust fan

Picture 8

Blocked exhaust

Picture 9

Water-damaged ceiling tiles, which are glued directly to ceiling

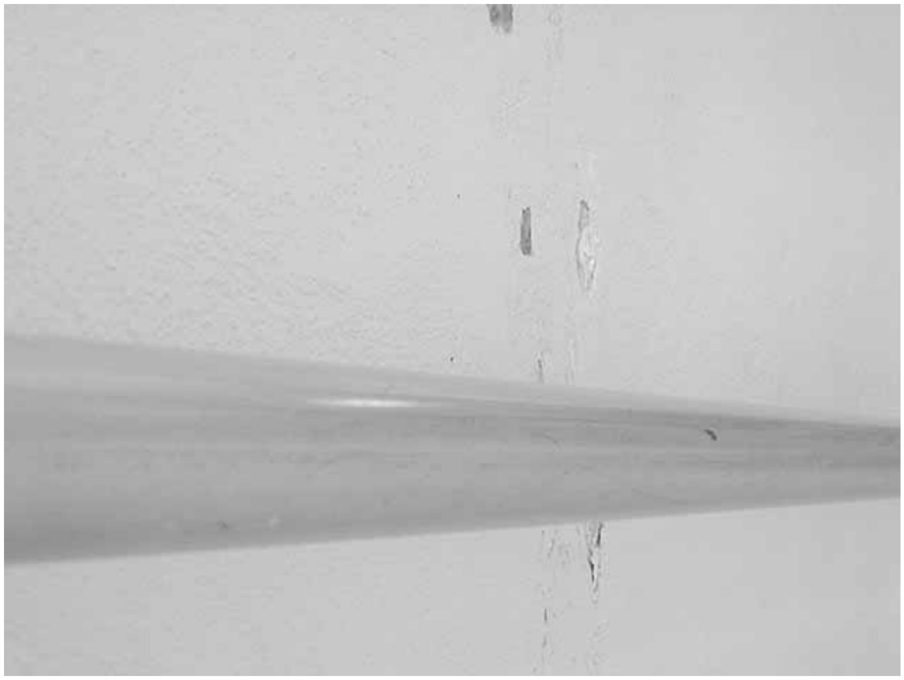
Picture 10

Plants near univent

Picture 11

Plant on porous materials

Picture 12



Efflorescence on ramp way walls

Picture 13

Ground level

Picture 14

Ground water channel

Picture 15

Clinging plant growth in exterior wall

Picture 16

Technology room doorway and staircase leading to storage and crawlspace areas

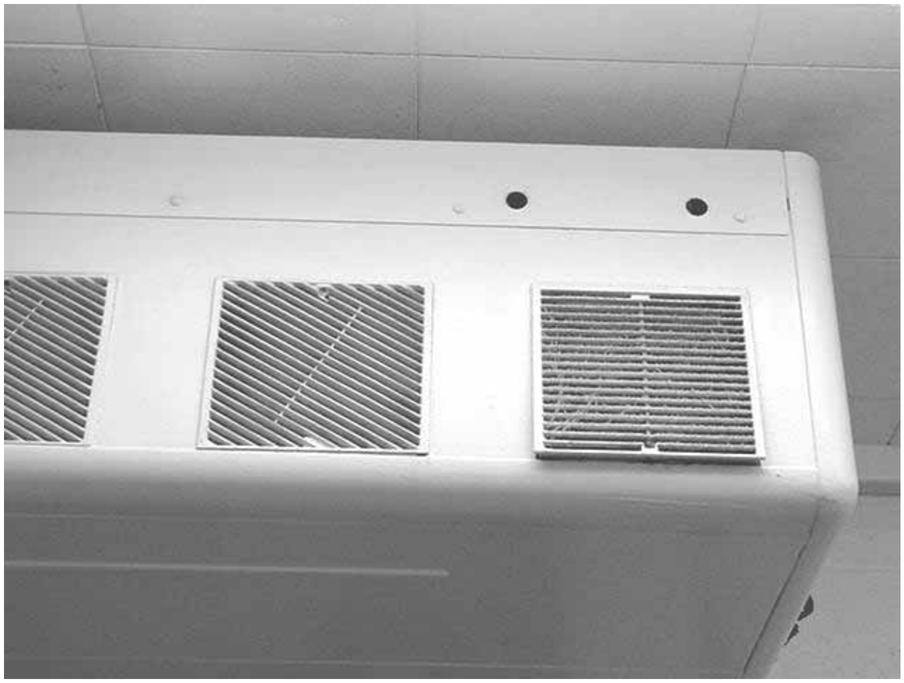
Picture 17

Plant growth against foundation

Picture 18

Auxiliary window fan in classroom 9

Picture 19

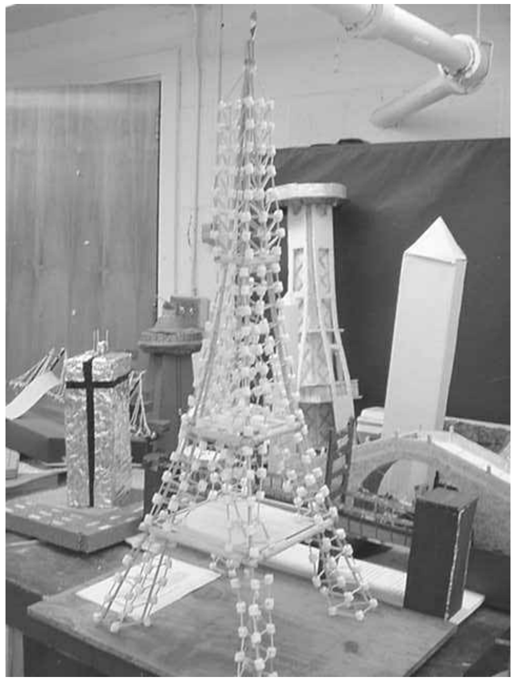


Dust on univent supply

Picture 20

Dust on blades personal fan

Picture 21



Food-based project

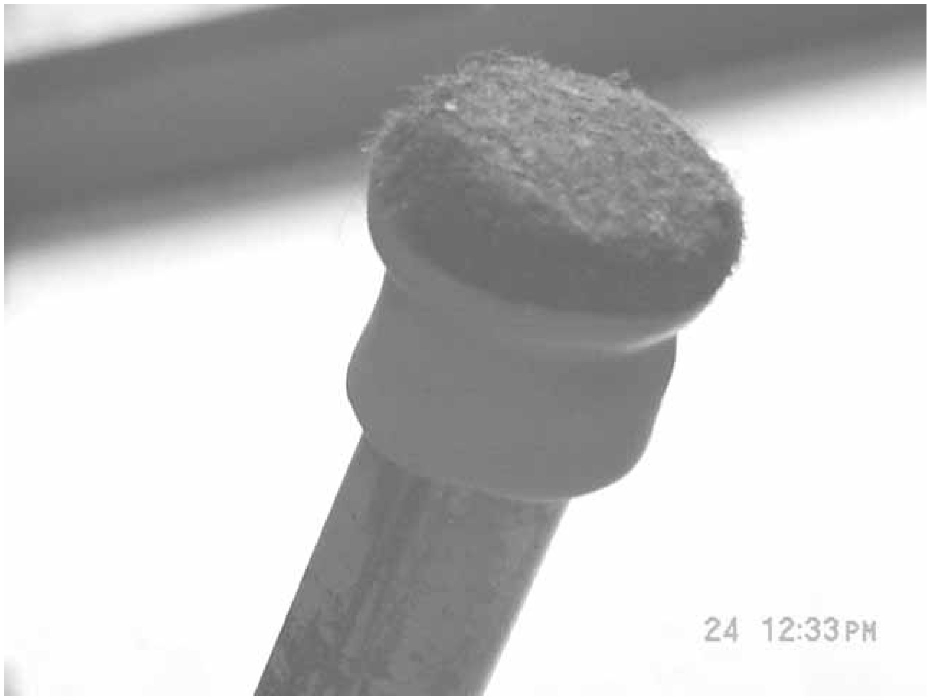
Picture 22

Tennis balls on chair legs

Picture 23

Amount of materials in classrooms

Picture 24



“Glides” for chair legs that can be used as an alternative to tennis balls

Essex Elementary/Middle School | **Indoor Air Results**

12 Story Street, **Manchester MA 01929** | **May 7, 2004**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background	0	77	49	347	ND	ND	12				Sunny; light breeze ~5mph.
art	21	71	51	653	ND	ND	30	Y # open: 0 # total: 4	Y wall (off)	Y wall (off)	Exterior DO, Exhaust blocked/occluded by furniture; clutter, FC re-use, kiln operating.
cafeteria	150	78	43	560	ND	ND	23	N # open: 0 # total: 0	Y wall	Y wall	Exterior DO
Counseling Office	1	76	43	786	ND	ND	19	N # open: 0 # total: 0	N undercut door	Y wall	Hallway DO; PF, clutter
D	1	77	44	652	ND	0.2	22	N # open: 0 # total: 0	N	Y ceiling	Hallway DO; PC, PF, wet toner copier.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems		

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12 Story Street, **Manchester MA 01929**

Table 1

Indoor Air Results
May 7, 2004

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
gym	0	73	47	704	ND	ND	36	N # open: 0 # total: 0	Y wall (off)	Y ceiling (off)	
main office	1	76	45	553	ND	ND	20	N # open: 0 # total: 0	N	Y wall	Hallway DO; PC.
media	3	74	46	472	ND	ND	22	Y # open: 3 # total: 4	Y univent (off)	Y closet	Hallway and Inter-room DO; Supply blocked/occluded by furniture, dirt/debris; Exhaust blocked/occluded by dirt/debris; window-mounted AC, DEM, PF, plants.
nurses' office	2	76	46	835	ND	ND	24	N # open: 0 # total: 0	N	Y wall	Hallway DO

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Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Essex Elementary/Middle School | **Indoor Air Results**

12 Story Street, Manchester MA 01929 | **May 7, 2004**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
principal's office	0	75	45	568	ND	ND	19	Y # open: 1 # total: 1	N	N	Hallway DO; window-mounted AC
Special Education Office	0	76	46	859	ND	ND	22	Y # open: 0 # total: 1	N	N	Hallway DO; window-mounted AC, plants.
Speech & Language	0	76	43	622	ND	ND	21	N # open: 0 # total: 0	N	Y ceiling	Hallway DO; CD.
teachers' lounge	0	77	44	507	ND	ND	13	N # open: 0 # total: 0	Y univent	Y wall	Hallway DO
1	18	77	44	826	ND	ND	24	Y # open: 3 # total: 3	Y univent	Y ceiling wall (off)	Hallway DO; Exhaust occluded with dirt/debris; CD, PF, TB, cleaners, FC re-use.

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									Supply	Exhaust	
2	0	76	43	491	ND	ND	22	Y # open: 2 # total: 3	Y (off)	Y (off)	Hallway DO; Exhaust VL; CD, PF, cleaners, FC re-use.
4	18	76	46	1121	ND	ND	29	Y # open: 0 # total: 3	Y univent	Y ceiling wall	Hallway DO; Exhaust VL; CD, DEM, TB, clutter, FC re-use, plants.
6	0	77	46	726	ND	ND	21	Y # open: 0 # total: 3	Y univent	Y ceiling wall	Hallway DO; Exhaust blocked/occluded by dirt/debris; Exhaust VL; DEM, PF, cleaners.
7	21	77	48	918	ND	ND	22	Y # open: 2 # total: 3	Y univent	Y wall closet	Supply blocked/occluded by dirt/debris; Exhaust blocked/occluded by clutter, dirt/debris; DEM, TB, aqua/terra, cleaners.

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									Supply	Exhaust	
8	21	77	46	792	ND	ND	22	Y # open: 3 # total: 4	Y univent (weak)	Y ceiling wall	Exhaust VL; DEM, PF, TB, clutter, plants.
9	21	79	42	698	ND	ND	17	Y # open: 2 # total: 2	Y univent (off)	Y ceiling wall	Hallway DO; Exhaust VL; CD, DEM, FC re-use, plants, chemical odor buildup when laboratory in progress; exhaust fan installed in window.
10	16	78	42	937	ND	ND	24	Y # open: 1 # total: 2	Y univent	Y ceiling wall	DEM, cleaners, clutter.
11	18	78	42	688	ND	ND	19	Y # open: 3 # total: 3	Y univent	Y wall closet	CD, DEM, PF, cleaners, plants, orange cleaning odor.

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12	7	76	42	517	ND	ND	14	Y # open: 1 # total: 3	Y univent	Y wall closet	Hallway DO; CD, DEM, PF, TB, plants.
13	20	80	44	992	ND	ND	20	Y # open: 3 # total: 3	Y univent (off)	Y wall closet	DEM, PF, clutter, items hanging from CT.
14	18	77	42	798	ND	ND	18	Y # open: 2 # total: 3	Y univent	Y wall boxes, VL	Hallway DO; CD, DEM, clutter, plants.
15	16	76	49	1191	ND	ND	24	Y # open: 0 # total: 3	Y univent (off)	Y wall	Hallway DO; Exhaust blocked/occluded by clutter; Exhaust VL; DEM, PF, cleaners, clutter, plants.

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									Supply	Exhaust	
16	23	75	56	2235	ND	ND	38	Y # open: 1 # total: 3	Y univent (off)	Y wall	CD, DEM, cleaners, clutter, plants.
17	5	76	44	613	ND	ND	15	Y # open: 1 # total: 4	Y univent (off)	Y wall (off)	Hallway DO; window-mounted AC, CD.
18	0	78	42	389	ND	ND	21	Y # open: 1 # total: 2	Y univent	Y ceiling	Hallway and **exterior** DO; Exhaust blocked/occluded by furniture, clutter, dirt/debris; #MT/AT: 1, CD, TB, cleaners, clutter, plants.
19	0	77	43	422	ND	ND	20	Y # open: 2 # total: 2	Y univent	Y ceiling	Hallway and **exterior** DO; Exhaust blocked/occluded by furniture, clutter; CD, DEM, aqua/terra, cleaners, food use/storage.

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									Supply	Exhaust	
20	4	77	44	597	ND	ND	16	Y # open: 1 # total: 2	Y univent	Y wall (off)	Exhaust blocked/occluded by clutter, plant(s); Exhaust VL; CD, FC re-use.

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